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BRAIN DAMAGE IN CRIMINALS

by

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Brain Damage in Criminals" submitted by Gwen Reimer in partial fulfillment of the requirements for the degree of Master of Arts.

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Date April 24 1975

ABSTRACT

The purpose of this study was to investigate one aspect of the relationship between brain dysfunction and criminal behavior. Because it was hypothesized that both frontal brain damage and verbal deficiency (subclinical aphasia) occur with greater frequency in the criminal population than in a control group, it was predicted that criminals would perform less well on a test of frontal brain damage and on a test of aphasia than would controls. Due to the effect of subclinical aphasia upon performance in the presence of frontal brain dysfunction it was predicted that the criminal groups would do even more poorly when scores for the test of frontal brain dysfunction were combined with scores on the test of aphasia than when scores on the test of frontal brain damage were used alone.

Sixteen males with a history of violent criminal offences, sixteen males with a history of non-violent criminal offences and sixteen males matched to the criminal groups for age and education were given the Wisconsin Card Sort Test (a measure of frontal lobe dysfunction) and the Token Test (a test of aphasia).

No significant differences were found between groups on either test. Although it is possible that the test instruments failed to detect actual differences between groups discussion centered on the more likely possibility that differences in brain functioning between criminals and non-criminals lies in the area of the limbic system -- and that the present study failed to find such differences due to the choice of a test instrument which taped only the non-limbic frontal area's function.

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INTRODUCTION

The purpose of this study is to investigate one aspect of the relationship between brain dysfunction and criminal behavior. Because it was hypothesized that both frontal brain damage and verbal deficiency (subclinical aphasia) occur with greater frequency in the criminal population than in a control group, it was predicted that criminals would perform less well on a test of frontal brain damage and on a test of aphasia than would controls. Due to the effect of subclinical aphasia upon performance in the presence of frontal brain dysfunction, it was predicted that the criminal groups would do even more poorly when scores for the frontal brain dysfunction were combined with scores on the test of aphasia than when scores on the test of frontal brain damage were used alone.

Further, since the behaviors which are characteristic of frontal brain dysfunction and subclinical aphasia were believed to occur in both violent criminals and non-violent criminals, but to be more prevalent and pervasive in the behavior of violent criminals, it was predicted that non-violent criminals would score better on the two tests than the violent criminals.

Background: Studies linking brain damage and criminal behavior

A link between brain dysfunction and criminal behavior has been made by the several studies which show that there is a higher incidence of abnormal EEG in the criminal population. Hill's (1963) review of the literature up to 1955 discloses that of the murderers tested in England, between 50% and 70% (depending on the study) had "abnormal"

EEG tracings but that similar studies conducted in the USA did not produce as clear a trend of results. Hill's review also shows that while there are several studies showing that the general criminal population (i.e. non-violent criminals) have a high proportion of brain dysfunction there are also several studies producing data which does not support this conclusion. In the period since Hill's review, Moamai (1966) found that 42.5% of a group of 120 juvenile delinquents showed abnormal EEG's as compared with 7.7% for their matched controls, and Williams (1969) found that of 333 adults in custody for crimes of aggression, 65% of those who were "habitual aggressives" and 24% of "non-habitual aggressives" had abnormal EEG's as compared with 12% for the population at large. These abnormal EEG's took the form of theta waves, especially in the frontal and temporal areas, which were interpreted by Williams (1969) as the result of limbic system lesions.

The care and criteria with which subjects are classified and EEG's are interpreted vary widely in these experiments. Williams' (1969) experiment appears to have been carefully executed, but even so, as Gibbs (1958) points out, EEG recording from the scalp is a gross measure and cannot be relied upon for localizing an area of brain dysfunction. There is one published study which used perceptual design tests, and neurological examination as well as an EEG (Wikler Dixon and Parker, 1970) to test 24 children with "scholastic behavioral problems" and their matched controls. The children with "scholastic behavioral problems" were found to have a significantly higher incidence of brain dysfunction on all three types of diagnostic

measure. This study, like the EEG studies, does not indicate the locus of damage, but does lend support to the idea that brain disorders may contribute to general maladjustment including criminal behavior. This relationship may explain in part, the disproportionate representation of the lower socio-economic class in the courts and jails (Warner and Lunt 1941, Clark and Wenninger 1962, and Blue 1948). As Montague (1972) points out, people of lower socio-economic status are often "culturally deprived" (i.e. less stimulated as infants and children) and undernourished (especially in regards to trace elements and vitamins). There is evidence (Dennis and Sayegh 1965, and Coursin 1968) that both these conditions produce below average psychomotor, physical and intellectual development due to less than optimal brain development.

Background: Observations linking frontal brain damage and criminal Behavior

In my experience, the behavior of many offenders is suggestive of a mild form of the impulsivity, distractability and lack of goal directed behavior which Luria (1966, pp. 225 - 228) describes as a result of frontal lobe dysfunction.

Also, in my experience, many offenders answer specific questions about themselves without apparent difficulty, yet cannot narrate a story in response to an open-ended question -- for example questions like "tell me what happened, how did you get caught?", "tell me about your schooling", elicit little response. Luria (1966, pp. 406

- 407) describes a severe form of deficit of what he calls predicative speech, as accompanying left frontal lobe damage, in which his patients show the same inability to narrate a story or describe a set of events in their own words yet are able to readily answer any question which requires only a "yes" or "no" or other short answer.

Frontal patients show a lack of critical regard for their own behavior (Luria and Homskaya 1964, Denny-Brown 1951, Luria 1966, p. 227). They appear undisturbed by their failures or problems and indeed it is this feature of frontal lobe dysfunction that is sought when lobotomies are performed on people with extreme obsessions, extreme anxiety or intractable pain. Similarly, in dealing with criminals, one finds that they "just don't care" -- they are unconcerned about what they do or, (except in the most immediate sense) what happens to them. They are remarkably unaware or inconsiderate of the consequences (to themselves) of their actions. Only a small proportion of the over 600 offenders interviewed by the writer would project the consequences of proposed actions, even when prompted in interview to do so. When asked about those actions that led them before the court, they stated that they "didn't think of" the possibility of apprehension. In those cases where preparations were made for the possibility of apprehension, the consequences of that apprehension were not considered. An inability to visualize consequences or anticipate events is a commonly noted feature of frontal lobe dysfunction (Pribram 1961, Denny-Brown 1951, Teuber 1964). Teuber has investigated this lack of ability to anticipate future events

through the frontal patients' performance on various spatial and orientation tasks and concludes that the "patient is not altogether devoid of capacity to anticipate a course of events, but cannot picture himself in relation to those events as a potential agent" (Teuber 1964, p. 440). Luria (in Luria 1964, p. 233 and in Luria and Homskaya 1964) takes the view that the frontal patient is unable to relate new experiences to his past experiences, i.e. he is unable to place events in context. Pribram (1961, 1971 pp. 337 - 345) discusses this deficit in terms of context dependent tasks. He points out that in higher mammals, frontal lobotomy impairs performance on discrimination reversal, passive avoidance, and delayed response tasks -- all of which require a response which is contingent upon context. Social (including criminal) behavior is certainly context dependent in nature.

A frontal patient's "poor performance" on context dependent tasks typically takes the form of perseveration of a response which was appropriate a short time previously but is now inappropriate. Some writers have attributed the frontal patient's difficulty in changing his response to impairment of the "abstract mental processes". Goldstein (1944) described frontal patients as able to learn new behaviors if the behavior is "concrete" and does not involve abstraction, and able to behave appropriately in familiar situations where the patient is not required to make decisions or where stereotyped behavior is called for, but reports lethargic, apathetic and perseverative responses in these patients in situations requiring decisions or shifting of response. Rokeach (1960, pp. 183, 184) discusses

"rigid thinking" (the tendency to continue the same response pattern when it is no longer appropriate) as a resistance to change of beliefs or "sets" or "habits" and relates this tendency to the "concreteness" or "rigidity" of the "authoritarian" personality. Frenkle-Brunswik (1949) found that perseveration, in a set which is maladaptive to the solving of a task, increased with frustration, especially in "concrete" or "rigid" people.

A somewhat different approach to perseveration is the work on reinforcement contingency changes. Frontal monkeys do not perseverate in a two choice discrimination experiment when the situation is quite unambiguous. Further, they do not perseverate if the situation's ambiguity is increased by increasing the number of response alternatives. They do perseverate however, when ambiguity is introduced to the situation in terms of reducing the reliability of the reinforcement (Pribram 1961, Poppen, Pribram and Robinson 1965). Also, frontal animals do not extinguish as readily as normal animals (Pribram 1961). Thus, frontal animals are less sensitive to changes in reinforcing conditions due to the frontal lesion's effect of reducing the attention-getting properties of reinforcers for that animal (Pribram 1971).

Luria and Homskaya (1964) have attributed the perseveration behavior of frontal humans to loss of orienting, i.e. to attention deficiencies. It has been shown that the orienting response has two components -- an alerting component and a registration component of which the GSR is a part (Bagshaw et al 1965) and that frontal monkeys

and humans have impaired GSR (Luria and Homskaya 1964, Luria, Pribram and Homskaya 1964 and Kimble, Bagshaw and Pribram 1965). These experiments led Pribram (1966) to suggest that the frontal lobes control the registration aspect of orienting to a stimulus and that this control takes the form of protecting the recall of the stimulus from interference. Further, he suggests that it does so by increasing the redundancy of the information input. He found (Pribram and Tubbs 1967) that "chunking" or grouping the changes in response required of a frontal animal results (in a delayed response alternation task) in a performance by a frontal monkey similar to that of a normal monkey.

In other words, forming a new set (breaking the response pattern that has been established) depends on redundancy of the information (reinforcements provide information) that the frontal animal receives. The old response persists (perseveration) until the new set is formed and the new set is formed more easily or more quickly the more the redundancy.

Both Pribram (1971, p. 341) and Luria (1966, pp. 250 - 266 and 1966a) report that verbal behavior or speech mechanisms (either covert or overt) assist humans in performance on context dependent tasks. Pribram describes this assistance in terms of introducing redundancy by verbal coding of the stimulus or response. Luria states that speech has a "self-regulatory function" and that frontal patients lose some of this self-regulatory function of speech. Pribram indicates that in frontals the speech coding helps to overcome their frontal

(perseverative) behavior but cannot always be used to a sufficient extent to produce "normal" performance.

There is evidence that criminals do tend to have a verbal deficit (Kolvin and Ounsted 1968 and Cattell 1950 p. 461). If Pribram's conception (that verbal coding protects the frontal human from perseveration) is correct, then criminals (who we believe to have frontal lobe dysfunction) are likely to fail on context dependent tasks due to reduced verbal coding.

Background: Violence and Limbic disorders

There are several studies showing a direct relationship between limbic system malfunction and violent behavior. Narabayashi et al (1963), Narabayashi (1972), Mark and Ervin (1970 pp. 70 - 85 and pp. 92 - 108) and Heimburger (1966) all report considerable behavior improvement in aggressive, excitable patients after stereotaxic amygdalectomy. Sano (et al 1966) found sedative effects in only 62% of the cases in which they lesioned the cingulate, thalamus, fornix or mesencephalic reticular areas, but found that all 22 patients in whom they lesioned the postero-medial hypothalamus became calm, passive and tractable. Mark and Ervin (1970 pp. 112 - 124) describe the case of a 14 year old girl who had murdered two infants, in whom recordings from an electrode implanted directly in the hippocampus were strikingly abnormal. They later determined (Mark, Ervin and Sweet 1972) that electrical stimulation of the amygdala and hippocampus via implanted electrodes had therapeutic effect on violent patients with

multiple temporal lobe epileptic foci, Williams (1969) found abnormal EEG tracings (which he interpreted as limbic in origin) in 49% of a sample of violent criminals.

Even if all violent crimes could be traced directly to limbic system dysfunction, less than 10% of all crimes committed in this city in February 1975 could be classified as even moderately violent ones (Edmonton City Police 1975). However, limbic system dysfunction could have an alternate mode of influence in criminal behavior. If a person had a hypothalamic dysfunction such that his appreciation of "pleasure" and "pain" was impaired, he might have problems in learning socially acceptable behavior because he received little social reinforcement (Stein and Wise 1971). My personal observations, mentioned earlier, of the lack of concern criminals show for themselves or anything else, is a frequently observed feature of amygdalectomy (Karli et al 1972, Gloor 1972, Kling 1972). In animals, it has been found that the amygdala is involved in the ability to learn on fear motivated (i.e. avoidance) tasks (Goddard 1964). Psychopaths have been found to be deficient in avoidance learning due to lack of fear mediation (Johns and Quay, 1962, Lykken 1957, Schachter and Latane 1964 and Quay and Hunt 1965) although Goldman et al (1971) found this to be true of only the "simple" psychopaths -- not the "hostile" or aggressive psychopath. Psychopaths are often engaged in criminal activity.

The direct interconnections between the limbic system and the frontal lobes and the reciprocal influence that these structures have

on each other (Luria 1966 pp. 231 - 232, Rosvold and Szwarcbart 1964, Nauta 1964) would indicate that violent criminals would also show "frontal" disturbances and non-violent criminals showing frontal disturbances may be doing so due to actual frontal dysfunction or to limbic dysfunction or both.

Test Instruments

Frontal lobe dysfunction has been found to result in deficits in sorting tasks and such sorting tasks have been found to be uniquely and particularly sensitive to frontal lobe dysfunction (Halstead 1940, Goldstein 1944, Weigl 1941 and Milner 1964). The Wisconsin Card Sort Test is one of these instruments. It is based on the Weigl Test but is more difficult (and thus more suitable for young adults) and yields quantitative scores rather than simple "pass-fail" data. The test itself and its administration are described under Method.

Verbal impairment has been tested by a number of devices (De Renzi and Vignolo 1962). The recently developed Token Test offers quantitative scoring and has been found to be a reliable and sensitive test of aphasia (Boller 1968, Boller and Vignolo 1966, De Renzi and Vignolo 1962, Orgass and Poeck 1966, Orgass and Poeck 1969, Swisher and Sarno 1969, and Van Dongen and Van Harskamp 1972). Hit rates of from 84% to 91% have been reported in these studies. The test itself and its administration are described under Method.

Hypotheses

1. The two criminal groups (violent and non-violent) will have higher

total error scores and higher perseverative error scores on a card sorting task measure of frontal lobe dysfunction (the Wisconsin Card Sorting Test) than the control group.

2. The violent criminal group will have higher total error scores and higher perseverative error scores in the Wisconsin Card Sorting Test than the non-violent criminal group.

3. The two criminal groups will have higher error scores on the Token Test of aphasia than the control group.

4. The violent criminal group will have higher error scores on the Token Test than the non-violent criminal group.

5. The difference between the criminal and the non-criminal groups will be larger when the scores of the WCS and the Token Test are combined than the difference between the criminal and non-criminal groups when the WCS test scores alone are used.

METHOD

The Subjects

Males who were over the age of 18 and who were on probation and/or parole were recruited through the offices of the National Parole Service and the Adult Probation Branch to serve as the experimental subjects. All experimental subjects had at least one conviction for an indictable, non-victimless offence under the criminal code and were volunteers for participation in this study. A total of 48 males were tested to obtain a sample of 32. Ten 16 and 17 year old subjects were discarded when it was discovered, part way through the data collection, that available control subjects were all over the age of 18. Five subjects were discarded when, upon record check, it was discovered they had only drug or summary convictions to their credit and one subject was discarded due to an error in test administration on the part of the experimenter. The sample of 32 consisted of two sub-groups: the first consisting of 16 persons who had a history of violent offences and the second consisting of 16 persons with a history of non-violent offences.

As a control group 20 males with approximately the same age and education as the subjects in the two experimental groups were recruited through a local school for upgrading and employment training (Alberta Vocational Center). No control subjects had any entries on their criminal record. The 16 "best matches" to the experimental sample (in terms of age and education" were selected for inclusion in

the control group. See results for subject characteristics.

All subjects were told that the experimenter was gathering data on a test of how people see things, and that the researcher wanted to see "how different groups of people do". If questioned, the experimenter explained further that people with criminal records may perform differently on the test than people who have never "been in trouble". All subjects were told that the testing was for research purposes only and that their responses were not to be given to (in the case of probationers or parolees) their supervising officer or anyone else at the supervising agency or (in the case of AVC students) to anyone connected with the school. Any subjects who appeared upset by their errors on the tests were told that the test is designed so that nobody can get it all right so they are not to worry that they got some wrong.

The Test Instruments and their Administration

All subjects were administered the Wisconsin Card Sort (WCS) Test and the Token Test (order balanced across subjects) after a preliminary screening for color blindness by having the subject name each of the colors of the tokens used in the Token Test.

Each subject was tested individually. Subjects recruited through the Adult Probation Branch were tested in an office there, subjects recruited through National Parole Service were tested in the boardroom of that office and the control subjects were tested in an office in the student services area of Alberta Vocational Center.

The Wisconsin Card Sort Test is this study's measure of frontal lobe dysfunction.

The WCS consists of four stimulus cards which are placed in a row in front of the subject and a pack of 128 response cards which are given to the subject. The four stimulus cards differ in color, form and number: one red triangle, two green stars, three yellow squares and four blue circles. The 128 response cards vary along the same dimensions. For example, a response card consisting of two red squares corresponds to the first stimulus card in color, the third stimulus card in form and the second stimulus card in number. Each subject was instructed to place each card from the pack beneath one of the stimulus cards -- wherever he "thinks it should go" and was told that the experimenter would inform him whether he was right or wrong. He was told to make what use he could of this information and to try to get as many right as possible. The subject was told "right" each time he sorted according to color until he achieved ten consecutive correct responses, then the sorting principle shifted to form <u>without warning</u> and color responses were declared "wrong". After ten consecutive correct responses to form the principle shifted to number, then back again to color, then form, then number. Thus, the sorting procedure continued until the subject successfully completed all six sorting categories or until all 128 cards had been used. For a more complete description of the test, see Grant and Berg (1948).

The Token Test is this study's measure of verbal impairment. It uses the following tokens: five large circles of five different

colors (red, blue, green, yellow, and white), five small circles (again of these five colors), five large rectangles (one of each color) and five small rectangles (one of each color). The original test consisted of five parts -- the first two of which consisted of commands such as "pick up the small yellow rectangle", "pick up the large red circle". In this study we used only the last three parts. "Part 3" consists of ten commands involving only the large tokens (the others are placed aside by the experimenter). The commands in "Part 3" are of the form "pick up the red circle and the green rectangle", "pick up the yellow rectangle and the white circle". The tokens are returned to the table after each command.

In "Part 4" of the Token Test, all twenty tokens are placed before the subject and he is given ten commands again involving picking up two different pieces. "Part 5" uses only the large tokens and uses twenty-one different commands involving more complex syntactic structures, for example "put the green rectangle beside the red circle" and "after picking up the green rectangle, touch the white circle".

For a complete account of the test, see De Renzi and Vignolo 1962. For a list of the "Part 5" commands see Appendix I.

DATA ANALYSIS AND RESULTS

First, an analysis of variance was carried out on the age and education level data to determine if the three groups differed on these measures. No differences were found and it was concluded that the matching of the control group to the criminal groups was satisfactory. Mean age and education levels for the three groups are shown in Table 1.

Table 1

Mean Age and Education of Subjects

	mean age (in years)	mean education (years completed)
Violent criminal	26.31	10.38
Non-Violent criminal	21.31	10
Control	23.75	9.94

The WCS yields three scores for each subject -- number of categories achieved, total number of errors and number of perseverative errors. Before analysis, error scores for the WCS were transformed according to the formula $x' = \sqrt{x + 0.5}$. Mean errors on the WCS are shown in Table 2 and mean number of categories achieved on the WCS is shown in Table 3.

Table 2

Mean Errors on the WCS (transformed scores)

	total errors	perseverative errors
Violent criminal	6.33	5.09
Non-violent criminal	6.36	5.94
Controls	5.77	4.84

Table 3

Mean Number of Categories Achieved

violent criminals	non-violent criminals	controls
3.75	4.62	4.44

Analyses of variance were carried out using each of the three scores (categories achieved, total errors and perseverative errors) as the dependent measure. Each analysis of variance was a 2 x 3 design i.e. factor A with three levels -- criminal violent, criminal non-violent and control -- with order of presentation of the tests as a control variable (factor B with two levels). No differences between the three groups was found on any of the three scores -- whether number of categories achieved, number of perseverative errors or total number of errors.

As can be seen from Table 4, the F values are very small. Because

overall F values were not significant, planned comparisons of combined criminal groups versus control and violent criminal versus non-violent criminal were not carried out.

Table 4

Mean Squares and F Values for WCS Dependent Variables (transformed scores)

	total errors	perseverative errors	categories achieved
MS_{group}	1.94	.62	3.94
MS_{order}	.21	.07	.19
MS_{gxo}	3.84	2.17	4.94
$MS_{s(gxo)}$	1.05	1.58	3.25
F_{group}	1.85	<1	1.21
F_{order}	<1	<1	<1
F_{gxo}	3.66	1.38	1.52

A similar analysis was carried out for the Token Test. Mean number of errors on the Token Test are shown in Table 5.

Table 5

Mean Number of Errors on the Token Test

	total errors	part 5 errors
violent criminal	6.7	5.14
non-violent criminal	7.19	5.37
control	6.01	4.37

A 3 x 2 analysis of variance design was utilized to determine if there were differences between the violent criminal, non-violent criminal and control groups on the Token Test. As shown in Table 6, no significant differences were found. With the thought that perhaps parts 3 and 4 of the Token Test are "too easy" to differentiate the groups another analysis was carried out using errors on part five alone. Again, as shown in Table 6, the differences between groups were not significant.

Table 6

Mean Squares and F Values for the Token Test

	total errors	part 5 errors
MS_{group}	5.77	4.34
MS_{order}	25.53	18.76
MS_{gxo}	41.4	13
$MS_{s(gxo)}$	15.93	5.39
F_{group}	< 1	< 1
F_{order}	1.6	3.48
F_{gxo}	2.6	2.41

The original experimental design had called for a multivariate analysis of variance using two dependent measures (Token Test error score and WCS perseverative error score) and a discriminant analysis

to determine which weighing of the two dependent measure discriminated the non-violent criminal, violent criminal and control groups from each other best, however, the lack of significant differences between the groups on the Token Test and the WCS made such a procedure pointless.

In general then, no differences between males with a history of violent criminal behavior, males with a history of non-violent criminal behavior and a control group were found on either the WCS or the Token Test.

DISCUSSION

There were no significant differences between violent criminals, non-violent criminals and controls on either the WCS or the Token Test. There are primarily two ways in which to account for the above results. The first is to assume that there are indeed no differences between criminals and non-criminals in the matters of frontal lobe dysfunction or aphasia (i.e. the groups are indeed from a common population). The second is to question whether the test instruments used failed to detect an actual difference between groups (i.e. a Type 11 error). Let us examine the second possibility first.

If there are indeed differences between criminals and non-criminals in terms of frontal lobe function or aphasia, would other measures have picked up these differences where the measures used failed to do so? This possibility is, of course, resolvable only by testing with other instruments. Certainly, as mentioned previously, sorting tasks are one of the best diagnostic measures of frontal lobe dysfunction available and the WCS or its parent version, the Weigl Card Sort, has been used previously with satisfactory hit rates in testing patients with brain damage due to accident or surgery. (Milner, 1964 and 1967). The literature on the Token Test reports highly satisfactory hit rates when it is used with patients with various brain lesions (Boller 1968, Boller and Vignolo 1966, De Renzi and Vignolo 1962, Orgass and Poeck 1966, Orgass and Poeck 1969, Swisher and Sarno 1969, Van Dongen and Van Harskamp 1972 and Poeck et al, 1974).

Apart from the test instruments themselves -- what of the test sample? Were the criminal groups really "criminal enough"? Two people in the non-violent criminal sample had only one conviction (that of theft over $200) and four had only two convictions (frauds and thefts). However, other individuals in the non-violent criminal group had far more than one previous conviction and about half had spent some time in a jail or penitentiary. In the violent criminal group four subjects had only one conviction on record -- in two cases the conviction was that of rape and in two cases the conviction arose out of attempts to kill another person. At least 10 of the 16 subjects in this sample had done penitentiary time (i.e. been sentenced to serve over two years) at some point in their criminal career. One fairly typical example of this group was a man who had served two penitentiary terms for theft, been to family court in regards to assault on his first wife, and was convicted of manslaughter after killing his second wife by beating her face against the side of a bathtub. This man obviously does belong in the violent criminal group. As noted earlier, subjects' whose records included only theft under $200 or possession of stolen property under $200 and people who had records only for victimless crimes were not included in the study.

Upon examination of the sample then, both the non-violent group and violent group appear to be composed of subjects with significant criminal histories.

Assuming the WCS and Token Test do indeed measure what they are purported to measure -- that is, frontal lobe dysfunction and aphasia

respectively -- how do we reconcile this study's lack of differences between criminals and non-criminals with the results of the numerous studies (cited in the introduction) which do show differences in brain dysfunction between criminals and non-criminals.

These studies, as noted previously, show a much higher incidence of abnormal EEG in the criminal population than in the population in general when the criminals being tested are murderers (Hill 1963). In relation to the prison population in general, Hill cites eight studies which found a higher than normal incidence of abnormal EEG and five studies which showed no unusual incidence of abnormal EEG. Williams (1969) found a much higher incidence of abnormal EEG -- in persons convicted of violent crimes. The two recent studies showing an increased incidence of abnormal EEG in criminals (Moamai 1966 and Wikler, Dixon and Parker 1970) both used children (delinquents or children with "scholastic behavioral problems") as their subjects. Gibbs (1958) and Hill (1963) note that abnormal EEGs "normalize" with age so that this high incidence of abnormal EEG in children may not be found later in their adult lives. It is possible then, that the abnormal EEGs which <u>were</u> found were the result of inclusion of a good proportion of violent criminals in the sample of some studies and that a higher incidence of abnormal EEG in the criminal population is a function of a high incidence of abnormal limbic system dysfunction in this population, rather than a high incidence of frontal dysfunction.

As noted earlier there are direct connections between the frontal

lobes and various limbic structures (Rosvold and Szwarcbart 1964, Nauta 1964) so it would be reasonable to speculate that dysfunctions in various parts of the limbic system (the amygdala for example) would influence the functioning of the frontal areas and perhaps produce dysfunction in the frontal areas. Following this line of reasoning, a high incidence of limbic system dysfunction in the criminal population could account for the mild "frontal" behavior noted earlier as observed in the criminal population. By this line of reasoning, however, one would then expect a measure of frontal lobe function to indicate some disturbance of the frontal lobe in a criminal group. The WCS is a sorting test -- and sorting tests are uniquely and particularly sensitive to frontal lobe dysfunction. (Halstead 1940, Goldstein 1944, Weigl 1941 and Milner 1964). More specifically, the WCS is a measure of perseveration of a certain type -- of a subject's ability to adjust to shifting reward contingencies. Deficiencies on delayed alternation tasks (and the WCS) have been found to be the result of lesions to the frontal lobe but particularly the dorsolateral frontal lobes. (Rosvold and Szwarcbart 1964, Nauta 1964). While the dorsolateral frontal cortex has projections to the anterior and dorsal portion of the head of the caudate nucleus and some areas of the hippocampus, it projects to areas different than the orbitol surface of the frontal lobes. The orbitofrontal cortex projects to the ventral portion of the caudate and to the amygdala (Rosvold and Szwarcbart 1964 and Nauta 1964). According to Rosvold and Szwarcbart (1964) abalation of the orbitofrontal cortex resulted in no deficits on

delayed alternation tasks (i.e. those tasks on which frontal monkeys traditionally perseverate or -- put another way -- those tasks on which frontal animals are unable to meet the shifting reward contingencies).

Table 7 gives a comparison of the data from this study to that from Milner (1964). As the table shows, the control subjects used in this study (with no known brain damage) were slightly more perseverative than Milner's control group of patients with posterior cortex lesions. This study's two criminal groups had perseverative errors falling between Milner's orbitofrontal lesion group and her dorsolateral frontal group. Unfortunately, Milner does not present her full data so further statistical analysis of the differences between groups is not possible.

Table 7

Mean Scores on the WCS: Comparison with another study*

group	mean number of errors** categories achieved	perseverative errors	non-perseverative errors	total errors
violent criminal (this study)	3.75	27.25	17.19	44.44
non-violent criminal (this study)	4.62	27.94	13.44	41.38
control (this study)	4.44	24.38	10.38	34.75
dorso-lateral frontal (Milner)	1.4	51.5	21.7	73.2
orbitofrontal & temporal (Milner)	4.9	12.0	15.6	27.6
posterior cortex	4.6	13	18	31.0

* Milner 1964 Patients tested post-operatively.

**raw scores -- not transformed

Because most lesions in human subjects are due to accident or disease - not experimentation - they are not neatly delineated. Thus human subjects with frontal lobe disorders could possibly show certain behaviors (perseveration on the WCS or delayed alternation tasks) due to their dorsolateral lesion and another set of (at this point undefined) behaviors due to their orbitofrontal lesions.

This study's data provides no evidence that members of the criminal population perseverate any more than matched controls (at least on the WCS) -- the data says nothing about their failure to see consequences, failure to learn in avoidance situations or "not caring". Thus it is possible that a high proportion of the criminal population does have limbic and/or frontal lobe damage -- the frontal lobe damage likely in the orbitofrontal area -- not the dorsolateral surface.

An alternative explanation for the author's observations of "frontal like" behavior on the part of her probationers and parolees is that such behavior was more a function of their social, educational and economic background rather than any brain dysfunction. This study's use of a control group which matched the criminal groups in age and education and also, generally, in terms of socio-economic background (in that the control group was drawn from the Alberta Vocational School), would mean that if such "frontal behavior" were a function of social and economic background rather than criminality that no differences would show up between the criminal and control groups in the study.

A review of those studies (cited in the introduction) which showed a higher incidence of abnormal EEG in the adult criminal population revealed that all found a higher incidence or abnormal EEG relative to the <u>general</u> population, not a control group matched for socio-economic status or even education. Moamai (1966) did compare his delinquents with a control group matched on sex (all male) and

age who were drawn from "une ecole professionelle" -- hardly likely to be of the same social or economic background as a group of delinquents.

Wikler, Dixon and Parker (1970) did use controls matched for sex, age, education, I.Q. and socio-economic status.

The above explanations of the study's results in relation to the WCS say nothing about this study's results on the Token Test. Kolvin and Ounsted (1968) and Cattell (1950 p. 461) both report criminals to have reduced verbal abilities. The only available observation here is that in relation to a group of controls matched for age and education, the group of criminals tested in this study did not do significantly worse than non-criminals. A recent study by Poeck et al, (1974) provides some interesting, if not very illuminating, comparisons regarding part 5 of the Token Test for the data gathered in the present study. Poeck et al, administered the Token Test to 100 patients with known brain damage (various locations) but who did not have any aphasia and also to 100 patients who had known brain damage with aphasia. As can be seen from Table 8 both samples of criminals used in the present study and also the control groups used in this study have a higher mean number of errors per item than the brain damaged subjects without aphasia used in Poeck's study, although they certainly do not reach the error level of his brain damaged with aphasia subjects. Further, in the present study all three groups (violent criminal, non-violent criminal and control) showed the <u>same</u> pattern of errors -- a pattern quite dif-

ferent to that reported by Poeck et al for either the brain damaged without aphasia or the brain damaged with aphasia, or by Whitaker and Noll (1972) for children aged 5 to 12 years (Table 9).

Table 8

Mean Errors on Part V of Token Test: Comparison with another study

group	mean number of errors*
violent criminal (this study)	24.4
non-violent criminal (this study)	22.94
control (this study)	20.83
brain damage without aphasia (Poeck)	16.38
brain damage with aphasia (Poeck)	68.71

* adjusted so that all groups effectively have 100 subjects

Table 9

Most Difficult Items on the Token Test Part V
(In Descending order of Difficulty)

This study	Poeck et al		Whitaker and Noll
	No Aphasia	Aphasia	
11	3	3	3
4	5	19	4
2	19,11,6	21	5
3	9	6	13
21	16	5	18
13		11	19
12			21

Unfortunately, because of extremely unequal n (this study used 16 subjects per group while Poeck et al had 100 subjects per group), statistical comparison of this pattern of responses would not be meaningful due to violation of the assumptions underlying such tests (Boneau 1960).

In conclusion, this study provides no evidence that criminals show such evidence of brain damage as exhibits itself in perseveration on a sorting task when compared with a group of matched control subjects and secondly this study provides no support to Cattell's (1950) oft quoted finding that criminals have impaired verbal abilities.

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APPENDIX I

Commands Used in "Part 5" of the Token Test

1. Put the red circle on the green square.
2. Put the white square behind the yellow circle.
3. Touch the blue circle with the red square.
4. Touch - with the blue circle - the red square.
5. Touch the blue circle and the red square.
6. Pick up the blue circle or the red square.
7. Put the green square away from the yellow square.
8. Put the white circle before the blue square.
9. If there is a black circle pick up the red square.
10. Pick up the squares, except the yellow one.
11. When I touch the green circle, you take the white square.
12. Put the green square beside the red circle.
13. Touch the squares slowly and circles quickly.
14. Put the red circle between the yellow square and the green square.
15. Except for the green one, touch the circles.
16. Pick up the red circle - no! - the white rectangle.
17. Instead of the white rectangle, take the yellow circle.
18. Together with the yellow circle, take the blue circle.
19. After picking up the green square, touch the white circle.
20. Put the blue circle under the white square.
21. Before touching the yellow circle, pick up the red square.

APPENDIX II

Data: Subjects and their responses

Subject Number	group*	order	age in years	grade	WCS errors total errors	perseverative errors	number categories achieved	Token Test Part 3	4	5
1	V	WCS	28	8	91	43	0	2	0	6
6	nv	WCS	23	8	40	28	6	0	0	4
7	V	TT	20	11	39	27	6	1	0	4
8	V	WCS	21	12+	46	29	3	0	0	6
10	V	TT	26	U of A 2 yrs.	53	38	3	0	0	2
12	nv	TT	19	11	28	22	6	1	2	5
13	nv	TT	20	Part 12	41	26	6	1	1	6
14	nv	WCS	18	9+	24	18	6	1	0	4
15	nv	WCS	19	9+	29	22	6	0	0	5
19	V	TT	19	12	63	52	3	1	0	2
22	nv	TT	18	7	50	27	4	0	0	6
24	nv	TT	20	11	14	8	6	0	0	7
26	nv	TT	18	9+	54	33	5	3	5	13
27	nv	WCS	19	11	65	41	2	0	2	7
29	nv	TT	49	12	46	37	4	1	2	7
30	V	WCS	20	12	46	25	4	0	2	0
31	V	WCS	23	11+	42	27	4	1	1	6
32	V	WCS	22	9+	11	9	6	0	0	1
34	V	WCS	43	9+	12	10	6	0	2	3
35	V	WCS	18	9+	60	23	5	0	2	3
36	nv	WCS	23	9	52	46	3	0	0	2
37	V	WCS	19	9+	87	40	0	0	0	5
38	nv	WCS	18	11	60	39	4	0	1	6
39	nv	WCS	18	9+	54	37	4	1	3	5

APPENDIX II continued

Subject Number	group*	order	age in years	grade	WCS errors: total errors	WCS errors: perseverative errors	WCS errors: number categories achieved	Token Test Part 3	Token Test Part 4	Token Test Part 5
40	nv	WCS	20	12	44	21	3	0	1	3
41	nv	TT	18	9	25	12	6	0	1	1
43	V	TT	40's	Tech. School	54	46	4	1	7	10
44	V	TT	42	11	64	35	0	1	1	9
45	nv	TT	21	9+	36	30	3	2	1	5
46	V	TT	28	5	17	12	6	2	3	7
47	V	TT	22	8+	16	13	6	1	6	8
48	V	TT	29	11	10	7	6	0	0	8
50	C	TT	23	9	53	36	4	0	1	4
51	C	TT	49	11	65	46	3	1	1	6
52	C	WCS	18	10	10	9	6	1	4	5
53	C	WCS	23	10	52	36	5	0	2	5
54	C	TT	19	11	41	24	3	0	1	7
55	C	TT	20	11+	38	23	4	0	0	2
56	C	WCS	22	9	25	12	6	0	3	5
57	C	WCS	23	11	18	14	6	0	0	4
58	C	TT	19	10	14	7	6	1	1	5
59	C	TT	20	10+	40	33	3	0	0	4
60	C	WCS	22	9	31	23	5	1	2	6
61	C	WCS	36	10	53	38	4	1	0	3
63	C	TT	18	10	46	35	4	0	1	3
64	C	TT	20	11	26	21	6	0	0	1
65	C	WCS	22	8	17	13	6	2	2	4
67	C	WCS	26	8	27	20	6	0	1	6

* V is violent criminal group
nv is non-violent criminal group
C is control group

APPENDIX III

Comparison Data on "Part 5" of the Token Test

item	this study			Poeck et al (1974)	
	violent criminal	non-violent criminal	control	brain damage no aphasia	brain damage aphasia
1	18.75	0	6.25	8	69
2	25	25	75	12	70
3	43.75	37.5	31.25	47	88
4	37.5	56.25	37.5	14	66
5	31.25	25	18.75	35	80
6	25	6.25	16.25	26	83
7	12.5	18.75	6.25	11	68
8	62.5	37.5	56.25	17	67
9	12.5	12.5	0	23	47
10	37.5	12.5	25	1	61
11	62.5	62.5	31.25	26	72
12	13.25	43.75	18.75	4	61
13	31.25	31.25	37.5	14	71
14	12.5	43.75	12.5	9	63
15	18.75	6.25	0	3	61
16	0	0	0	22	60
17	12.5	6.25	0	7	58
18	0	6.25	6.25	6	63
19	6.25	6.25	18.75	26	87
20	12.5	0	6.25	13	62
21	18.75	43.75	43.75	20	86
means	24.4	22.92	20.83	16.38	68.71

Note: numbers refer to number of subjects getting that item wrong. Subjects adjusted to 100 subjects in each group, each subject tries all 21 items.